Getting TEMOA running with CPLEX and SQLite

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The purpose of this document is to formally record how to get TEMOA running with CPLEX and SQLite so that it can be quickly transferred to another machine. The steps are based on http://www.temoaproject.org/download/ and Joseph Saylor's readMe file with elaborated steps to make it more straightforward for a user with little or no python experience. These steps were developed for a Windows machine.

Notes: anything in italics are code segments; skip installation of any software already present on the machine

1. Install **Git**
    a. Purpose: Version control software
        i. https://www.slideshare.net/HubSpot/git-101-git-and-github-for-beginners
        ii. http://product.hubspot.com/blog/git-and-github-tutorial-for-beginners
    b. Download latest version from https://git-scm.com/
    c. Installation instructions
        i. Select the second option "Use Git from the Windows Comand Prompt" to ensure git is added to your computer's path
        ii. Select "Use the OpenSSL library"
        iii. Select "Checkout Windows-style, commit Unix-style line endings"
        iv. Select "Use Windows' default console window"
        v. Leave configuration options as-is
        vi. Finish installing.
2. Install **Anaconda2 for Python 2.7**
    a. Purpose: Distribution of the Python language and common libraries
    b. Download the latest version of Anaconda2 for Python version 2.7 https://www.anaconda.com/download/
    c. Install using default settings
3. Install **Pyomo**
    a. Purpose: Library from Sandia National Labs for optimization modeling
    b. Installation steps:
        i. Start Anaconda2 terminal (Programs>Anaconda2>Anaconda Prompt)
        ii. Verify version of Python
            python --version
            1. If Python 2.7.X does not appear, then troubleshooting is necessary
        iii. Install Pyomo
            pip install pyomo
            pip install pyomo.extras
            Note: If errors – may need to first install MS Visual C++ Compiler for Python https://www.microsoft.com/en-us/download/details.aspx?id=44266
        iv. Exit Anaconda
            exit

4. Install **CPLEX**
    a. Purpose: Powerful linear optimization solver
    b. Navigate to CPLEX website https://www.ibm.com/developerworks/community/blogs/jfp/entry/CPLEX_Is_Free_For_Students?lang=en
    c. Select the appropriate link either a) Students or b)Teachers, researchers and university staff
    d. Follow the steps to create an account using your institutional email address (i.e. abc123@virgina.edu) and download CPLEX
    e. Install using default settings
5. Install **DB Browser for SQLite**
    a. Purpose: Viewer for SQLite files
    b. Download the latest version http://sqlitebrowser.org/
    c. Install with default settings
6. Install **TEMOA**
    a. Select the directory where TEMOA will be installed and record the pathname, i.e. "C:\"
    b. Decide what name to give the folder with temoa files, "temoa" is recommended and is used below
    c. Start Windows command prompt terminal (Start, type cmd, hit enter)
    d. Navigate to the path
        cd pathname
    e. Clone git (copies all of TEMOA's files from the repository)
        git clone https://github.com/TemoaProject/temoa/
7. Install **GLPK**
    a. Purpose: Required to prepare input files for CPLEX
    b. Download the latest version: https://www.gnu.org/software/glpk/ or for Windows: https://sourceforge.net/projects/winglpk/
    c. Unzip and copy files to location of your choice
    d. Record directory to w32 folder (for 32 bit OS) or w64 folder (for 64 bit OS)
    e. Add directory to path
    f. Test glpsol works
        i. Start windows command prompt (Start, type "cmd", enter)
        glpsol --help
        ii. Output should resemble this:

```
Options specific to MIP solver:
   --nomip           consider all integer variables as continuous
                     (allows solving MIP as pure LP)
   --first           branch on first integer variable
   --last            branch on last integer variable
   --mostf           branch on most fractional variable
   --drtom           branch using heuristic by Driebeck and Tomlin
                     (default)
   --pcost           branch using hybrid pseudocost heuristic (may be
                     useful for hard instances)
   --dfs             backtrack using depth first search
   --bfs             backtrack using breadth first search
   --bestp           backtrack using the best projection heuristic
   --bestb           backtrack using node with best local bound
                     (default)
   --intopt          use MIP presolver (default)
   --nointopt        do not use MIP presolver
   --binarize        replace general integer variables by binary ones
                     (assumes --intopt)
   --fpump           apply feasibility pump heuristic
   --proxy [nnn]     apply proximity search heuristic (nnn is time limit
                     in seconds; default is 60)
   --gomory          generate Gomory's mixed integer cuts
   --mir             generate MIR (mixed integer rounding) cuts
   --cover           generate mixed cover cuts
   --clique          generate clique cuts
   --cuts            generate all cuts above
   --mipgap tol      set relative mip gap tolerance to tol
   --minisat         translate integer feasibility problem to CNF-SAT
                     and solve it with MiniSat solver
   --objbnd bound    add inequality obj <= bound (minimization) or
                     obj >= bound (maximization) to integer feasibility
                     problem (assumes --minisat)

For description of the MPS and CPLEX LP formats see Reference Manual.
For description of the modeling language see "GLPK: Modeling Language
GNU MathProg". Both documents are included in the GLPK distribution.

See GLPK web page at <http://www.gnu.org/software/glpk/glpk.html>.

Please report bugs to <bug-glpk@gnu.org>.
```

8. Optional: Install **Notepad++**

a. Purpose: Text editor with increased abilities for searching and highlighting code syntax
b. Download latest version from https://notepad-plus-plus.org/
c. Install using default settings
d. It is recommended to make this the default program for opening *.txt files

9. Create test cases

a. Navigate to the directory "temoa_model" in the directory where TEMOA is installed
b. Open config_sample
c. Save As a new file (if using Notepad++)
  i. File name: "config_sample_cplex"
  ii. Save as type: "All Types(*.*)"
d. *Confirm the below lines are set as follows*
  i. Line 11: *--input=db_io/temoa_utopia.sqlite*
  ii. Line 15: *--output=db_io/temoa_utopia.sqlite*
e. *Update the code as follows*
  i. Line 19: *--scenario=test_run_cplex*
  ii. Line 35: *--solver=CPLEX # Optional, indicate the solver*
f. *Save*
g. Save As a new file (if using Notepad++)
  i. File name: "config_sample_glpk"
h. *Update the code as follows*
  i. Line 19: *--scenario=test_run_glpk*
  ii. Line 35: *--solver=GLPK # Optional, indicate the solver*

10. Run test case
    a. Start Anaconda2 terminal (Programs>Anaconda2>Anaconda Prompt)
    b. Verify version of Python

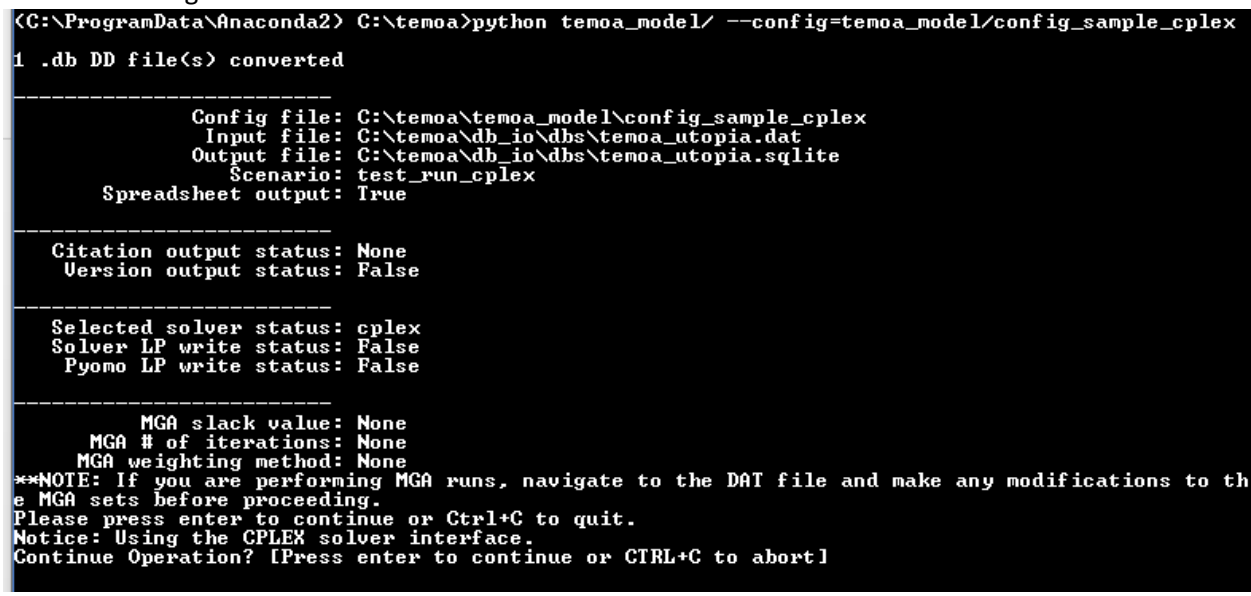
        python --version

        i. If Python 2.7.X does not appear, then troubleshooting is necessary
    c. Change directory to the location of temoa (shown as "C:\temoa")

        cd C:\temoa
    d. Run test case 1

        python temoa_model/ --config=temoa_model/config_sample_cplex
    e. Expected Results

    After submitting command:



After hitting enter to continue:

```
      0.064974              V_FlowOut[2010,summer,night,DSL,TXD,2000,TX]
      0.331534              V_FlowOut[2010,summer,night,DSL,TXD,2010,TX]
      0.63                  V_FlowOut[2010,summer,night,ELC,RL1,2010,RL]
      0.18909099999999995   V_FlowOut[2010,summer,night,GSL,TXG,2000,TX]
      0.388178              V_FlowOut[2010,summer,night,GSL,TXG,2010,TX]
      0.31527383999999997   V_FlowOut[2010,summer,night,HCO,E01,1980,ELC]
      0.10588152585659287   V_FlowOut[2010,summer,night,HCO,E01,2000,ELC]
      0.346156839921284     V_FlowOut[2010,summer,night,HCO,E01,2010,ELC]
      0.072250255000000001  V_FlowOut[2010,summer,night,HYD,E31,1980,ELC]
      0.021675076499999998  V_FlowOut[2010,summer,night,HYD,E31,1990,ELC]
      1.7164848484848485    V_FlowOut[2010,summer,night,ethos,IMPDSL1,1990,DSL]
      2.499                 V_FlowOut[2010,summer,night,ethos,IMPGSL1,1990,GSL]
      2.397850643055865     V_FlowOut[2010,summer,night,ethos,IMPHCO1,1990,HCO]
      0.2935166609375       V_FlowOut[2010,summer,night,ethos,IMPHYD,1990,HYD]
      5.444339999999999     V_FlowOut[2010,winter,day,DSL,RHO,1990,RH]
     11.05467               V_FlowOut[2010,winter,day,DSL,RHO,2000,RH]
     14.498879999999998     V_FlowOut[2010,winter,day,DSL,RHO,2010,RH]
      0.259974              V_FlowOut[2010,winter,day,DSL,TXD,2000,TX]
      1.3265339999999999    V_FlowOut[2010,winter,day,DSL,TXD,2010,TX]
      0.89354397000000001   V_FlowOut[2010,winter,day,ELC,E51,1980,ELC]
      6.3                   V_FlowOut[2010,winter,day,ELC,RL1,2010,RL]
      0.7565909999999997    V_FlowOut[2010,winter,day,GSL,TXG,2000,TX]
      1.5531780000000002    V_FlowOut[2010,winter,day,GSL,TXG,2010,TX]
      1.26147383999999998   V_FlowOut[2010,winter,day,HCO,E01,1980,ELC]
      0.42365321210086915   V_FlowOut[2010,winter,day,HCO,E01,2000,ELC]
      3.3455148963991306    V_FlowOut[2010,winter,day,HCO,E01,2010,ELC]
      0.289087755           V_FlowOut[2010,winter,day,HYD,E31,1980,ELC]
      0.086726326499999999  V_FlowOut[2010,winter,day,HYD,E31,1990,ELC]
     51.1507                V_FlowOut[2010,winter,day,ethos,IMPDSL1,1990,DSL]
      9.998999999999999     V_FlowOut[2010,winter,day,ethos,IMPGSL1,1990,GSL]
     15.720756089062498     V_FlowOut[2010,winter,day,ethos,IMPHCO1,1990,HCO]
      1.1744190046875       V_FlowOut[2010,winter,day,ethos,IMPHYD,1990,HYD]
      2.7216720724346066    V_FlowOut[2010,winter,night,DSL,RHO,1990,RH]
      5.526323963782697     V_FlowOut[2010,winter,night,DSL,RHO,2000,RH]
      7.248113963782695     V_FlowOut[2010,winter,night,DSL,RHO,2010,RH]
      0.13002599999999997   V_FlowOut[2010,winter,night,DSL,TXD,2000,TX]
      0.6634659999999999    V_FlowOut[2010,winter,night,DSL,TXD,2010,TX]
      1.26                  V_FlowOut[2010,winter,night,ELC,RL1,2010,RL]
      0.378408999999999983  V_FlowOut[2010,winter,night,GSL,TXG,2000,TX]
      0.776822              V_FlowOut[2010,winter,night,GSL,TXG,2010,TX]
      0.6309261599999999    V_FlowOut[2010,winter,night,HCO,E01,1980,ELC]
      0.21189016038768343   V_FlowOut[2010,winter,night,HCO,E01,2000,ELC]
      1.6732593256217674    V_FlowOut[2010,winter,night,HCO,E01,2010,ELC]
      0.144587245           V_FlowOut[2010,winter,night,HYD,E31,1980,ELC]
      0.0433761735          V_FlowOut[2010,winter,night,HYD,E31,1990,ELC]
     25.5723303030303       V_FlowOut[2010,winter,night,ethos,IMPDSL1,1990,DSL]
      5.00099999999999994   V_FlowOut[2010,winter,night,ethos,IMPGSL1,1990,GSL]
      7.862736393779533     V_FlowOut[2010,winter,night,ethos,IMPHCO1,1990,HCO]
      0.5873856828125       V_FlowOut[2010,winter,night,ethos,IMPHYD,1990,HYD]

Selected Coopr solver plugin does not give constraint data.


If you use these results for a published article, please run Temoa with the '--how_to_cite' comma
nd line argument for citation information.
```

f. Run test case 2

python temoa_model/ --config=temoa_model/config_sample_glpk

g. Expected Results

After submitting command:

```
(C:\ProgramData\Anaconda2) C:\temoa>python temoa_model/ --config=temoa_model/config_sample_glpk

1 .db DD file(s) converted

-------------------------
              Config file: C:\temoa\temoa_model\config_sample_glpk
               Input file: C:\temoa\db_io\dbs\temoa_utopia.dat
              Output file: C:\temoa\db_io\dbs\temoa_utopia.sqlite
                 Scenario: test_run_glpk
       Spreadsheet output: True

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   Citation output status: None
    Version output status: False

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   Selected solver status: glpk
   Solver LP write status: False
    Pyomo LP write status: False

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          MGA slack value: None
     MGA # of iterations: None
      MGA weighting method: None
**NOTE: If you are performing MGA runs, navigate to the DAT file and make any modifications to th
e MGA sets before proceeding.
Please press enter to continue or Ctrl+C to quit.
Notice: Using the GLPK solver interface.
Continue Operation? [Press enter to continue or CTRL+C to abort]
```

After hitting enter to continue:

```
      0.767312205777877     V_FlowOut[2010,summer,night,HCO,E01,2010,ELC]
      0.072250255           V_FlowOut[2010,summer,night,HYD,E31,1980,ELC]
      0.0216750765          V_FlowOut[2010,summer,night,HYD,E31,1990,ELC]
      1.71648484848485      V_FlowOut[2010,summer,night,ethos,IMPDSL1,1990,DSL]
      2.499                 V_FlowOut[2010,summer,night,ethos,IMPGSL1,1990,GSL]
      2.39785064305586      V_FlowOut[2010,summer,night,ethos,IMPHCO1,1990,HCO]
      0.2935166609375       V_FlowOut[2010,summer,night,ethos,IMPHYD,1990,HYD]
      5.44434               V_FlowOut[2010,winter,day,DSL,RHO,1990,RH]
     11.05467               V_FlowOut[2010,winter,day,DSL,RHO,2000,RH]
     14.49888               V_FlowOut[2010,winter,day,DSL,RHO,2010,RH]
      0.259974              V_FlowOut[2010,winter,day,DSL,TXD,2000,TX]
      1.326534              V_FlowOut[2010,winter,day,DSL,TXD,2010,TX]
      0.89354397            V_FlowOut[2010,winter,day,ELC,E51,1980,ELC]
      6.3                   V_FlowOut[2010,winter,day,ELC,RL1,2010,RL]
      0.756591              V_FlowOut[2010,winter,day,GSL,TXG,2000,TX]
      1.553178              V_FlowOut[2010,winter,day,GSL,TXG,2010,TX]
      1.26147384            V_FlowOut[2010,winter,day,HCO,E01,1980,ELC]
      0.423653212100869     V_FlowOut[2010,winter,day,HCO,E01,2000,ELC]
      3.34551489639913      V_FlowOut[2010,winter,day,HCO,E01,2010,ELC]
      0.289087755           V_FlowOut[2010,winter,day,HYD,E31,1980,ELC]
      0.0867263265          V_FlowOut[2010,winter,day,HYD,E31,1990,ELC]
     51.1507                V_FlowOut[2010,winter,day,ethos,IMPDSL1,1990,DSL]
      9.999                 V_FlowOut[2010,winter,day,ethos,IMPGSL1,1990,GSL]
     15.7207560890625       V_FlowOut[2010,winter,day,ethos,IMPHCO1,1990,HCO]
      1.1744190046875       V_FlowOut[2010,winter,day,ethos,IMPHYD,1990,HYD]
      2.72167207243461      V_FlowOut[2010,winter,night,DSL,RHO,1990,RH]
      5.5263239637827       V_FlowOut[2010,winter,night,DSL,RHO,2000,RH]
      7.2481139637827       V_FlowOut[2010,winter,night,DSL,RHO,2010,RH]
      0.130026              V_FlowOut[2010,winter,night,DSL,TXD,2000,TX]
      0.663466              V_FlowOut[2010,winter,night,DSL,TXD,2010,TX]
      1.26                  V_FlowOut[2010,winter,night,ELC,RL1,2010,RL]
      0.378409              V_FlowOut[2010,winter,night,GSL,TXG,2000,TX]
      0.776822              V_FlowOut[2010,winter,night,GSL,TXG,2010,TX]
      0.630926159999999     V_FlowOut[2010,winter,night,HCO,E01,1980,ELC]
      0.211890160387683     V_FlowOut[2010,winter,night,HCO,E01,2000,ELC]
      1.67325932562177      V_FlowOut[2010,winter,night,HCO,E01,2010,ELC]
      0.144587245           V_FlowOut[2010,winter,night,HYD,E31,1980,ELC]
      0.0433761735          V_FlowOut[2010,winter,night,HYD,E31,1990,ELC]
     25.5723303030303       V_FlowOut[2010,winter,night,ethos,IMPDSL1,1990,DSL]
      5.001                 V_FlowOut[2010,winter,night,ethos,IMPGSL1,1990,GSL]
      7.86273639377953      V_FlowOut[2010,winter,night,ethos,IMPHCO1,1990,HCO]
      0.5873856828125       V_FlowOut[2010,winter,night,ethos,IMPHYD,1990,HYD]

Selected Coopr solver plugin does not give constraint data.


If you use these results for a published article, please run Temoa with the '--how_to_cite' comma
nd line argument for citation information.
```

h. Exit Anaconda

Exit

Addendum – Background on TEMOA

DeCarolis, J., Hunter, K., Sreepathi, S., "The TEMOA Project: Tools for Energy Model Optimization and Analysis," International Energy Workshop 2010, 21-23 June 2010, Stockholm, Sweden.

Hunter, K., Sreepathi, S., DeCarolis, J., "Modeling for insight using Tools for Energy Model Optimization Analysis (Temoa)", Journal of Energy Economics, 40 (2013), 339-349.

Addendum – Background on creating TEMOA configuration files

- Example located in temoa_model\config_sample
- Config files can have any file extension, .txt makes it easy to read in
- There are a number of flags that you need to specify (mandatory and optional)
- first two are source of input and source of output: where to direct
- if running from database, input and output will be there same
- there will be a set of database tables that contain input data that you specify for your energy system
- blank tables will contain output data
    a. two different flags to specify text file as input and database as output if wanted
- name the scenario: model stores results in output tables and indexes by scenario name so results get aggregated an you can query by name of scenario (mandatory)
- need to specify path to db_io folder (database input/output) for necessary files and scripts
- optional files:
    a. save excel: saves output to excel workbook where each sheet contains different sets of data, dividing by sectors with each sector having a different sheet for activity and capacity
    b. save text file: saves log of information from shell
    c. solver: specify solver if needed
    d. keep pyomo lp file: lp file gets generated by pyomo and set to solver to solve – helps with debugging
    e. modeling to generate alternatives: for uncertainty analysis
        i. if choosing to run modeling to generate alternatives (mga): need to specify slack file, iteration number, how many mga iterations you want to generate, and the method by which you want to update the objective function: either integer or normalized weighting